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ANALYTICAL ABSTRACTS OF CURRENT LITERATURE.

SUMMARY OF CURRENT PRE-CAMBRIAN NORTH AMERICAN LITERATURE.*

Cross[1] describes a series of hornblendic, micaceous and chloritic schists, on the eastern side of the Arkansas river, near Salida, Col. In places these grade into massive rocks. They are cut by granitic and pegmatitic veins, as well as by dykes of porphyry. A detailed microscopical study leads to the conclusion that the rocks are a metamorphosed volcanic series. The whole constitutes a part of a single anticline. The schists are unconformably below the Silurian, and as the known Cambrian in Colorado is a thin series of quartzites and shales conformable with the Silurian, the Salida schists are considered as pre-Cambrian. The relations of the schists to the Archean complex are not exposed, but they are probably a continuation of the hornblende-schists of Marshall Pass. Greenish schists are found at Tin Cup Pass, and near the town of Tin Cup is a highly crystalline marble interbedded with the green schists, and fine grained gneissoid rocks, showing that metamorphosed sedimentary rocks do exist among the crystalline schists of the Sawatch Range. Taking into account all the facts it is thought that the schists and massive rocks of the Salida section probably represent a great series of surface lavas, erupted in Algonkian time.

Smyth (C. H.)[2] describes the rocks near Gouverneur, New York, as consisting of gneiss, granite, limestone, and sandstone, with small amounts of associated schists. The gneiss is the oldest rock of the region, underlying the other formations. It sometimes grades into a true granite, the passage being gradual. The two are regarded as different phases of the same rock, either the granite being an unchanged remnant of a Plutonic mass from which the gneiss is derived, or the result of fusion of the gneiss. Evidence of unconformity between the beds of the limestone and the foliation of the gneiss was found in two localities, and was indicated in several others; there is no evidence of irruptive contacts between the gneiss and limestone; the gneiss shows no evidence of sedimentary origin; therefore, the simplest hypothesis, but requiring more proof, is that the gneiss is an eroded metamorphosed plutonic rock, upon which the limestone was deposited. The marble is coarsely crystalline, and in age is next to the gneiss. Near the base of the limestone, and interbedded with it, are peculiar schistose rocks, which, while completely crystalline and resembling igneous rocks in composition, are indicated by their field relations to be of sedimentary origin. Near Gouverneur an outcrop of limestone contains abundant fragments of black schist, scattered through the limestone in a most irregular manner, and making up, perhaps, one-third of the rock. This and other outcrops show that the schist fragments are remains of once continuous schist layers, which have been completely shattered in the course of metamorphism, since between the continuous belts of schist and the Gouverneur locality there is every possible gradation. While the schists show the effects of foldings, contortions, stretchings and shattering, the limestone shows no traces of it, it appearing to have been a plastic mass in which the schists moved with considerable freedom. The conspicuous result of metamorphism in the limestone is crystallization. In the limestones are also pegmatitic veins, which have been much shattered by the dynamic action, reducing them to small lumps of quartz and feldspar, scattered through the limestone. So far as observed the pegmatite yields to strain only by fracturing, not showing preliminary contortions, so general in the schistose layers.

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*Continued from page 314.

[1] Series of Peculiar Schists near Salida, Col., by Whitman Cross. In Proceedings of Col. Scientific Soc., Jan., 1893, pp. 1–10.

[2] A Geological Reconnaissance in the vicinity of Gouverneur, by C. H. Smyth, Jr. In Transactions N. Y. Academy of Sciences, vol. xii., April, 1893, pp. 97–108.

In the southern part of the area examined is a granite, not grading into gneiss, and which breaks through the limestone, causing great disturbance in strike and dip, enclosing masses of the rock many feet in diameter, and metamorphosing this rock to some extent. The sandstone at Gouverneur was found in direct contact with the limestone. Here it appears that the limestone surface has been subjected to erosion before the sandstone was deposited upon it. In confirmation of this are seen narrow irregular cracks extending several feet into the limestone, which have been filled with sandstone. The limestone was evidently completely lithified when the sandstone was deposited and sifted into it, and this implies discordance. This unconformity proves that the limestone is older than the upper Cambrian, the data being wanting for any more definite determination of its age. The metamorphism of the rocks of the limestone-bearing series occurred before upper Cambrian time, but the sandstone is metamorphosed, and this metamorphism must therefore belong to post-Potsdam time.

Comments.—The inquiry rises whether the second metamorphism spoken of, that of the sandstone, is produced merely by interstitial cementation, or is dynamic metamorphism. If the first is found to be the explanation, so far as the paper gives any evidence, all of the igneous activity and dynamic metamorphism are pre-Potsdam.

[1] Wadsworth gives a sketch of the iron, gold and copper districts of Michigan. The Azoic or Archean rocks are divided from the base upward into Cascade, Republic and Holyoke formations. These divisions are placed in order as equivalent to the fundamental complex, lower Marquette series and upper Marquette series of Van Hise. They are unconformable and represent three different geological ages. The Keweenawan is divided into two divisions, both of which are placed in the Cambrian; the Lower Keweenawan, 25,000 ft. of interbedded conglomerates and lava flows, with some intrusives; Upper Keweenawan, 12,000 feet of sandstones and shales, not separable from the Potsdam or Eastern sandstone.

The Azoic or Archean system consists of rocks formed (1) by mechanical means, (2) by eruptive agencies, (3) by chemical action.

The Cascade, or oldest formation of sedimentary and eruptive rocks, consists, commencing with the oldest, of gneissoid granites or gneiss, basic eruptives and schists, jaspilites and associated iron ores, and granites, although the above arrangement may be considered no more than a hypothesis, and it is probable that the jaspilites and iron ores will be found to belong to the Republic formation. It is also probable that the Cascade formation itself will prove to be composed of two or more distinct geological formations, as shown by the fact that the chief rock of the Huron Mountains appears to be a gneissoid granite, rather than a true sedimentary gneiss. True sedimentary gneisses are found in the Huron Bay and Cascade districts. In the former area they contain fragments that closely resemble the gneissoid granites, and thus they appear to be formed from the debris of those rocks. If, however, the gneissoid granites are metamorphosed eruptive rocks, and not true gneisses (which are restricted to metamorphosed sedimentary rocks), this fact proves only that the gneisses are younger in order of time, but not of necessity of younger geological age. Similar statements apply to the breaks between the Cascade and Republic formations, and the break between the Republic and Holyoke formations. In the Huron Bay, Menominee and other districts the Cascade formation holds intrusive granites. Amphibole-schists are also found intrusive in the gneisses in the Cascade area. In the Marquette area the amphibole schists are cut by felsite or quartz-porphyry.

Much of the granite and felsite appear to have been erupted during the time of the Cascade formation, and perhaps even later. On the Cascade range hornblende-gneiss cuts the country rock. These dykes are cut by other dykes containing crystals of feldspar, while both are cut by gray granite, that is in turn cut by red granite.

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[1] A Sketch of the Geology of the Iron, Gold and Copper Districts of Michigan, M. E. Wadsworth, Rep. State Board Geol. Sur., Michigan, 1891–2; pp. 75–174; Lansing, 1893. Also, see Annual Reports 1888–1892, ibid., pp. 38–73.

The Republic formation, commencing with the oldest division, is divided roughly as follows: Conglomerate-breccia and conglomerate-schist; quartzite; dolomite; jaspilite and iron ore; argillite and schist; granite and felsite; diabase; diorite and porodite; porphyrite. At the base of the Republic formation is a series of conglomerates and conglomerate-schists, which pass into hydrous mica-schists. Near Palmer, the coarse conglomerate rests on the gneiss to the south, and is overlaid to the north by quartzite, fragmental jaspilite and quartz-schist. The dip is about 40° northward. The conglomerate contains numerous pebbles of gneiss, as well as some of granite, diorite, schist and quartz veins. Near the Volunteer mine quartzite immediately overlies the basal conglomerate, and in other places reposes directly on the Cascade formation.

The quartzite in the Menominee district, running from Sturgeon river along Pine river to Metropolitan, is thought to belong to the base of the Republic formation, since it is found at various places close to the gneiss and granite, dipping away from them, and is cut by dykes of granite in Sec. 12, T. 41 N., R. 30 W. The dolomite occupies a low horizon, either interbedded with the quartzite or occupying its place. The fundamental ore and jaspilite appears to belong, stratigraphically, to the Republic formation. The most of the jaspilite of the formation is of detrital origin, being originally conglomerates, breccias, sands, muds, which have been subsequently chemically acted upon by percolating waters, since in the Cascade range the jaspilite and ore form layers which are frequently interlaminated with quartzite. The jaspilite of Negaunee and Ishpeming has failed to reveal any evidence that it is sedimentary, although the associated argillite and schist are in part at least clearly sedimentary. The argillite and schists are directly associated with the jaspilite and iron ore. In places they grade up into the fragmental jaspilite, and in other places are interbedded with it. They also succeed the latter rocks and overlie them. These argillites and schists are older than the diorites of the district, and are cut by them.

The Holyoke formation has the following succession, as far as known, commencing with the base: Conglomerate breccia and conglomerate schist; quartzite; dolomite; argillite; graywacke and schist; granite and felsite; diabase, diorite and porodite; peridotite, serpentine and dolomite; melaphyr or picrite; diabase and melaphyr. The conglomerate at the base of the Holyoke contains granitic material, as well as fragments from the jaspilite. In many places the unconformity between the Republic and Holyoke formations is most marked, being seen at many of the mines. In many places, also, the Holyoke formation overlaps the Republic, and is in contact with the granite and gneiss of the Cascade. Associated with the Holyoke conglomerate is a quartzite which includes the Mt. Mesnard and Teal Lake quartzites. In Sec. 20, T. 47 N., R. 26 W., and Secs. 8 and 19, T. 49 N., R. 28 W., near Silver Lake and in other places, sediments of the Holyoke formation have sifted down into the fissures and joints of the preëxisting rocks, when they have a dyke-like character. For such formations the term "clasolite" is proposed. The dolomite of Mt. Mesnard and thence to Goose Lake, while lithologically, like that placed in the Republic formation, is doubtfully referred to the Holyoke. Argillite, graywacke and mica-schist occur extensively in the Holyoke, constituting the upper horizon. It is doubtful whether any granite or felsite of Holyoke age exists in the Marquette district.

Diabase, diorite, porodite, and peridotite occur abundantly, belonging both to the Republic and Holyoke formations. According to Mr. Seaman, diabase dykes of the Gogebic area are probably the same as those that cut the overlying sandstones of the Keweenawan, from which it is concluded that the Keweenawan lava flows are the effusive equivalents of the Holyoke diabase dykes.

The soft hematites of the region are produced by secondary enrichment at places where the water could best act, being at points of fracturing or in basins. The silica of the lean material has been leached out, and in its place iron oxide substituted. Gold and silver veins are discussed, and a classification of ore deposits given.

The Eastern or Potsdam sandstone rests unconformably on the Azoic. This includes the unaltered horizontal sandstone, which is free from dykes of eruptive material, and the Keweenawan, which consists of lava flows alternating with sandstones and conglomerates, largely derived from the former. Above, and conformably with the Eastern sandstone, near L'Anse, is limestone of Silurian age, as shown by its fossil contents. On Keweenaw Point the Eastern sandstone dips toward, and passes under, the interstratified sandstones and lavas of the Keweenawan. At or near the contact is a fault. However, at Douglas, Houghton and Hungarian rivers, it is thought not to be at the contact, and consequently that the Eastern sandstone underlies the Keweenawan lava, but the Eastern sandstone may contain two or more sandstones of different ages, which may perhaps be considered as the most probable explanation of all the evidence. In Sec. 13, T. 46 N., R. 41 W., on the South Trap range, a nearly horizontal, soft, friable micaceous sandstone is found near the interbedded Keweenawan melaphyr and indurated sandstone. This soft sandstone contains numerous spherical spots very common in the Eastern sandstone, but not found in the Keweenawan. In the soft sandstone are found pebbles and large angular fragments of indurated sandstone, which Mr. Seaman thinks could only have been derived from the adjacent indurated sandstone. The rocks of the Trap range here exposed are believed by Mr. Seaman to hold a position near the top of the Keweenawan series, and he concluded that the soft sandstone belongs to a distinct and later geological age than the Trap range.

The character and origin of the copper deposits are discussed.

Comments.—The major structural conclusions independently reached by the Michigan Geological Survey are nearly identical with those which have been published by the officers of the United States Geological Survey. The same may be said as to the origin of the iron ores. Upon a few points there is, however, a difference of opinion.

The unconformity which exists between the Lower Marquette and the Basement Complex marks a distinct geological age, whether gneissoid granites composing the latter are metamorphosed eruptives or metamorphosed sedimentary rocks. It is true that a sedimentary formation resting upon an eruptive, and deriving material from it, is no evidence of a geological break if the eruptive is a surface rock and has not been altered before the overlying formation was deposited. If, however, the eruptive is a deep-seated rock, or has been so sheared and folded as to take on a schistose structure before the deposition of the succeeding formation, and has consequently reached the surface by erosion, the discordance may mark as great a geological break as an unconformity between a metamorphosed sedimentary rock and an unaltered overlying series.

That there is more than one geological period represented in the Cascade formation seems unlikely, and in a later note by Dr. Wadsworth this idea is apparently abandoned. If any gneisses of the Huron Mountain prove to be unconformably upon, and to have derived material from, an older gneissoid granite series, it is probable that this new series will be found to be equivalent to the Lower Marquette or Upper Marquette series rather than to belong to the Cascade formation.

Jaspillite and ore are tentatively placed as one of the kinds belonging to the Cascade formation or Basement Complex, although the major portion of them are placed in the higher series. No large areas of this rock yet discovered would be here placed by the reviewer. The jaspillite of Ishpeming and Negaunee doubtfully referred to the Cascade is believed to be a sedimentary deposit of the same age as similar rocks of the Lower Marquette series.

That the jasper near the base of the iron-bearing formation at Cascade is interlaminated with layers of fragmental material is not sufficient evidence that the jasper is or has been derived from a mechanical sediment. The inferior formation of the lower Huronian is usually, if not always, a clastic deposit, resting as it does unconformably upon an earlier series of granites, gneisses and schists. This fragmental formation usually grades up into the non-fragmental formation of the iron-bearing member, and before continuous pure non-clastic sediments are reached there are often several alternations of the two kinds of deposits. Such occurrences are exactly analogous to the interlaminations of limestone with shale or sandstone at the transition horizon which frequently occurs when a limestone formation rests upon a sandstone formation.

As to the age of the Keweenawan, this series is placed by Dr. Wadsworth as a lower part of the Potsdam, but is regarded by the reviewer as resting unconformably below the Potsdam, and as belonging to a different geological period. This question is one of great complexity, which can not here be discussed in detail. However, Dr. Wadsworth refers the Keweenawan so doubtfully to the Potsdam that the difference can hardly be said to be a serious one. The statement that the most probable explanation of all the phenomena at Keweenaw Point is that the Eastern sandstone is of different ages can have but one meaning—that a part of this so-called Eastern sandstone belongs to the Potsdam, and this Potsdam is later than, and unconformably upon, the Keweenaw series, which latter includes another part of the Eastern sandstone. Put in another way, Dr. Wadsworth extends the term Eastern sandstone to cover all of the sandstone exposed until the Traps are reached. That is, the break between the Potsdam and Keweenawan is in places a short distance away from the Traps. This admits the difference in geological age between the main area of Potsdam sandstone and the Keweenawan, and merely shifts the boundary line between the two a short distance. It is notable that the most important new evidence presented upon the question is that obtained by Mr. Seaman, Dr. Wadsworth's assistant. Near the South Range he finds outcrops which he regards as Eastern sandstone, holding indurated fragments derived from adjacent ledges of upper Keweenawan sandstones, and hence believes the Eastern sandstone to represent a later geological age.

It appears to the writer very doubtful whether the large number of members given for the Republic and Holyoke series will be found to be general for the Lower Huronian and Upper Huronian on the south shore of Lake Sueprior, although each may be found at some locality.

Wadsworth[1] states that recent work renders it probable that the Azoic or Archean of Northern Michigan is divisible into five unconformable formations. The tentative arrangement, commencing with the oldest, with the parallel formations, as determined by the United States Geological Survey, is as follows:

MICHIGAN GEOL. SURVEY.	U. S. GEOL. SURVEY.
Cascade Formation.	Fundamental Complex.
Republic Formation Mesnard Formation	Lower Marquette series.
Holyoke Formation Negaunee Formation	Upper Marquette series.

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[1] Subdivisions of the Azoic or Archean in Northern Michigan," by M. E. Wadsworth. In Am. Jour. of Sci., vol. xlv., No. 265, Jan., 1893, pp. 72, 73.

Comments.—The suggestion of the two additional unconformities in the Huronian of the Marquette district is so tentative that no criticism of it is necessary. The suggestion implies that Dr. Wadsworth thinks this outcome the most probable one. It appears to the writer, however, that it is far more probable that the true explanation is that there are only three unconformable pre-Keweenawan series. The additional unconformities are probably suggested by the considerable local variation in the character of both the Lower Huronian and Upper Huronian series, so that in different parts of the district the same series has very different aspects.

Lane[1] holds that certain of the ore bodies of the Marquette district are produced by abstracting iron oxide from amphibolites and depositing this material at other places. The water is regarded as upward moving, hence the ore bodies rest upon the diorites as foot walls. It is not denied that in other places the iron is derived from a carbonate, or that silicia is replaced by the iron oxide. At the Volunteer mine the ore seems in part to have replaced the sandstone.

Bell reports on the Sudbury mining district:[2] The rocks are divided into three groups, in ascending order: (1) A gneiss and hornblende-granite series — Laurentian. (2) A series comprising quartzites, massive graywackes, often holding rounded and angular fragments; slaty graywackes, with and without included fragments; drab and dark-gray argillites and clay-slates; dioritic, hornblendic, sericitic, felsitic, micaceous and other schists; and occasionally dolomites, together with large included masses or areas of pyritiferous greenstones. This group constitutes the ordinary Huronian of the district. (3) A division consisting of a thick band of dark-colored silicious volcanic breccia and black slate (generally coarse), overlaid by drab and dark-gray argillaceous and nearly black, gritty sandstones and shaly bands. The breccia is underlaid in places by quartzite conglomerate. (4) In addition to these, dikes of diabase and gabbro cut through all the foregoing, and are, therefore, newer than any of them, although they may not belong to a later geological period.

Flanking the Huronian rocks on the southeast is gneiss, and on the northwest a mixture of gneiss and hornblende-granite. The first of these rocks is of the characteristic Laurentian type, but the hornblende-granite and quartz-syenite on the northwest are not always characteristic of the Laurentian. These rocks, however, pass into the gneiss in such a way, and are mingled with them both on a large and small scale, that it was impossible to separate them. Within the Huronian trough, and parallel with it, is also a tongue of gneiss and hornblende-granite two or three miles wide and thirty-nine miles long.

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[1] Microscopic characters of Rocks and Minerals." A. C. Lane. Rep. State Board Geol. Sur., Mich., for 1891-2, Lansing, 1892, pp. 176-183.

[2] Report on the Sudbury Mining District, by Robert Bell. Annual Rep. Geol. & Nat. Hist. Sur. of Canada for 1889–90. Vol. v, Part F, p. 95, with a geological map.

The Huronian division forms a part of the great Huronian belt, extending from Lake Superior and Lake Huron nearly to Lake Mittassini. The bedding of the Huronian is usually nearly vertical, or stands at high angles. Occasionally the rocks have been sheared by pressure. Graywacke-conglomerate, in places full of rounded pebbles of gray quartz-syenite, is found on the Blue River branch of the Spanish River, Lot 2, Con. III. In the township of Hyman is an Augen-gneiss which is evidently a metamorphorsed clastic, as it forms a part of the quartzite and graywacke series. The line of junction between the Laurentian and Huronian is unusually straight. West of Lake Wahnapitae, along the contact, there is evidence of great disturbance and crushing, the rocks of the two series being much broken up and intermixed. It is not improbable that at the junction line is a considerable fault.

The third division is less altered, and is in a distinct basin running from the township of Trill northeastward to near the South Bay of Lake Wahnapitae, a distance of 36 miles, with a breadth of 8 miles in its central portion. These rocks are perhaps unconformable to the older Huronian rocks on which they rest, and may be Upper Huronian, or possibly lower Cambrian.

Along Onaping Lake and River, and along Straight Lake, are Huronian outliers. The principal kinds of rocks in the first basin are slate conglomerates, with well-rounded pebbles and boulders, mostly of binary granite, quartz, quartzite and schists; and coarse arenaceous or graywacke conglomerate, together with some pale-pink quartzites and blueish and greenish-gray felsites, argillites and slates. The principal rocks of the second basin are graywacke-schists, quartzites, quartzite or graywacke-conglomerates, green schists, hard sandstones, greenstones, and some dolomites. In the conglomerates are pebbles of graywacke and hornblende-granites like the prevailing varieties found in situ in the region, black slates and black and white quartz. On Lot 4, Con. III, Moncrieff, is the junction of the Laurentian red hornblende-granite and the graywacke.

It is concluded that the Huronian rocks of the Sudbury district are largely of volcanic nature, although many of them have been rearranged by water; hence they may be termed pyroclastic. The graywackes consist of granite debris more or less comminuted by the modifying action of water. Under this name is included many varieties of rocks, ranging from those which approach quartzites to others approaching argillites. The largest fragments are usually of red or gray aplite. As a general rule, the different divisions of the Huronian rocks do not maintain their thickness very far on the strike, but diminish more or less rapidly, their place at the same time being filled by a corresponding thickening of other members of the series.

The trappean rocks of the district consist of (1) extensive masses, together with many of smaller size, incorporated with the other Huronian rocks, and probably contemporaneous with them; and (2) dikes which cut through all the members of the series. There are nearly fifty areas of diorite, two principal belts of diabase, and a belt of slaty, greenish diorite, which in places becomes brecciated, and includes fragments, from large boulders down to small pebbles, consisting principally of quartzites, granites, and syenites.

Very numerous details are given, which cannot be summarized.

Comments.— The conclusion of Bell, that the Huronian is divisible into two divisions which are probably unconformable, corresponds with the more recent conclusions of those who have studied the Huronian of the Lake Superior region and the original Huronian of the north shore of Lake Huron. The area reported upon being a continuation of the Lake Huron Huronian, it is not surprising to find the dual character of this series continue.

No light is given upon the character of the floor upon which the earliest sedimentary rocks must have been deposited. That at several places are found water-deposited conglomerate which bear well-worn pebbles and boulders of granite, syenite, etc., which in one case are said to be exactly like the granite found in situ, seems conclusive evidence that granite and syenite existed in the region in a consolidated condition before the Huronian members containing this detritus were laid down. A part of these conglomerates clearly belong to Bell's older division of the Huronian, but this series is not divided into formations, consequently we have no information as to whether or not these conglomerates are at the bottom of the series.

Williams,[2] gives microscopical notes on various rocks from the Sudbury district. The sedimentary rocks are found to include those which are plainly clastic, those which are clastic but partially re-crystallized, and those which are highly crystalline, but probably derived from clastics. In the last division are placed felsite, gneiss-conglomerate, and gneiss. The eruptives, including various acid and basic deep-seated and surface rocks, also show extensive metamorphism and re-crystallization. Placed among the highly crystalline rock, probably derived from the clastics, are certain felsites, gneiss-conglomerates, and gneisses. Certain granites, gneisses and schists are of uncertain origin, but give no indication of clastic derivation.

C. R. VAN HISE.

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[2] "Notes on the Microscopical Character of Rocks from the Sudbury Mining District, Canada," by George H. Williams. Annual Rep. Geol. & Nat. Hist. Sur. of Canada for 1889–90, vol. V, Part F, Appendix I, pp. 55–82.